APGC-TDR-63-27

Engineering Investigation of Ignition Failure Rate of TAU-15/B Infrared Target Flares

by Russell A. Bunn, Capt, USAF

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DEPUTY FOR AEROSPACE SYSTEMS TEST

AIR PROVING GROUND CENTER

AIR FORCE SYSTEMS COMMAND • UNITED STATES AIR FORCE

EGLIN AIR FORCE BASE, FLORIDA

FOREWORD

This test, APGC Project 7826W28, was conducted at Eglin Air Force Base, Florida, by the Target Systems Test Directorate, Deputy for Aerospace Systems Test, Air Proving Ground Center. The test was authorized by APGC Operations Directive No. 7826W28 in response to letter from Detachment 4, Aeronautical Systems Division, dated 3 May 1962, subject: "TAU-15/B IR Flare." Testing was initiated on 30 August 1962 and was completed on 1 March 1963.

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ABSTRACT

This test was established at the request of the Target Development Laboratory, Detachment 4, Aeronautical Systems Division. Unsatisfactory operation of the TAU-15/B infrared target flares had been observed when these flares were employed at high subsonic speeds and high (35,000 ft) altitude. The primary difficulty was failure of a significant percentage of the flares to burn after successful operation of the ignition squibs. Since it was believed that age of the flares may have affected their operational performance, this test was conducted to investigate the ignition failure rate of TAU-15/B flares which had been in storage since the July-October 1960 manufacturing period. Specific objectives of the test were to determine the ignition failure rate during flight at 35,000 ft altitude and mach 0.7 as well as under simulated flight conditions in an altitude chamber.

It was concluded that performance of the TAU-15/B flares varies from one production lot to another and with altitude and the internal temperature of the individual flares. Results obtained under simulated altitude conditions in the altitude chamber correlated reasonably well with those obtained during airborne tests.

Recommendations include elimination of U.S. Flare Lot 3-1 TAU-15/B flares from USAF inventories and replacement of all TAU-15/B flares by an improved substitute as soon as possible.

PUBLICATION REVIEW

This technical documentary report has been reviewed and is approved.

A T Culbertson

A. T. CULBERTSON
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SECTION 1 - INTRODUCTION

Seventeen thousand TAU-15/B infrared target flares were manufactured for the Air Force under Contract AF 42(600)-20343 by the U.S. Flare Division, Atlantic Research Corporation, Saugus, California. Prior to full-scale production of these flares, the contractor performed preproduction laboratory tests on a pilot lot of the flares under the same contract during the winter of 1959. Limited engineering tests of these first articles also were conducted by the Air Force in the spring of 1960. Delivery of the flares to the Air Force was completed in 1961.

In the spring of 1962, Detachment 4, Aeronautical Systems Division, and the Target Systems Test Directorate, Air Proving Ground Center, reported unsatisfactory operation of the flares when they were employed at high subsonic speeds and high (35,000 ft) altitudes. The primary difficulty was failure of the flares to burn after apparently successful operation of the electrical squib contained in the aft end of each flare.

Since it was considered that the age of the TAU-15/B flares may have affected their operational performance, this test was conducted to investigate the ignition failure rate of the flares which had been in storage since the July-October 1960 manufacturing period. Specific objectives of the test were to:

1. Determine the ignition failure rate of the TAU-15/B flares at 35,000 ft altitude and mach 0.7.

2. Determine whether the flare ignition failure rate obtained in the APGC Armament Strato Chamber could be correlated to that obtained in flight.

In accordance with the test directive only samples from two production lots of flares were to have been investigated during the test unless significant differences were found to exist among the flares. Accordingly, samples from U.S. Flare (U.S.F.) production lots 3-1 and 3-17 were selected for testing. Since the results obtained with these flares differed considerably during testing, the test was expanded to include sample flares from production lots 3-5 and 3-10. No investigation was made of the infrared characteristics of the flares during this test.

SECTION 2 - DESCRIPTION

The TAU-15/B infrared target flare (Fig. 1) was designed to provide infrared augmentation for TDU-4/B, TDU-6/B, TDU-9/B, TDU-15/B, and TDU-17/B tow targets. It is identified in USAF Stock List 1300 as Flare, Aerial Infrared, TAU-15/B, Federal Stock No. 1370-670-5793-LY04, and is presently classified tentative standard. The listed unit price is $15.00. The flare is similar to the Naval Ordnance Test Station 711A flare in size and composition and is manufactured in accordance with military specification MIL-F-9791 (USAF), dated 4 November 1958.

The flare is 10 1/4 in. long, 2 in. in diameter (stepped to 1 3/4 in.) and weighs approximately 1.7 lb. Its case is a phenolic tube with a 6-in.-long metal jacket fitted over the tube. The metal jacket is provided to retard consumption of the case during burning, thus preventing subsequent unintentional ignition of adjacent flares or target damage. The ignition system includes a male bayonet-type electrical connector, a Mk 2 mod 0 squib or equivalent, and two lead wires extending from the electrical connector along a groove cut in the inner surface of the case to the squib. The squib is buried in approximately 5 grams of loose ignition composition so that when the squib is fired the ignition

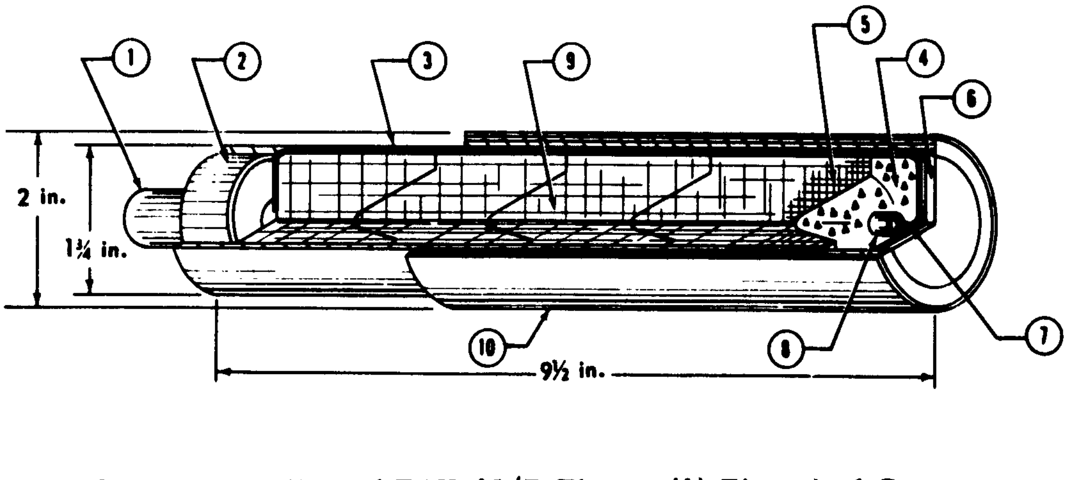

Fig. 1: Cutaway View of TAU-15/B Flare: (1) Electrical Connector, (2) Phenolic Base Plug, (3) Canvas Base Phenolic Tube, (4) Loose Ignition Composition, (5) First Fire Composition, (6) Potted Closure Plug, (7) Lead Wires, (8) Squib, (9) Main Illuminant, (10) Metal Outer Jacket.

composition is ignited. The burning of this composition then ignites a first fire composition which, in turn, ignites the main illuminant. The electrical connector is positioned in the center of the phenolic base plug which is cemented into the forward end of the flare case. The plug is further retained in the case by a hollow locking pin inserted diametrically through the case and plug. Two small projections are located on opposite sides of the electrical connector for aligning and retaining the flares in the flare holder sockets. The aft end of the flare is capped by a potted closure plug which is normally blown free of the flare upon firing of the squib.

A flare is normally ignited after the towed target has been launched and the target control receiver has been given a signal to light one or more flares. The control receiver allows an ignition voltage of approximately 6 vdc to be applied to the electrical connector of the flare. The squib then fires and begins the ignition process. The electrical characteristics of the squib are as follows:

1. 100% no-fire current - 1.0 ampere.

2. 100% all-fire current - 2.0 amperes (if applied for longer than 20 milliseconds).

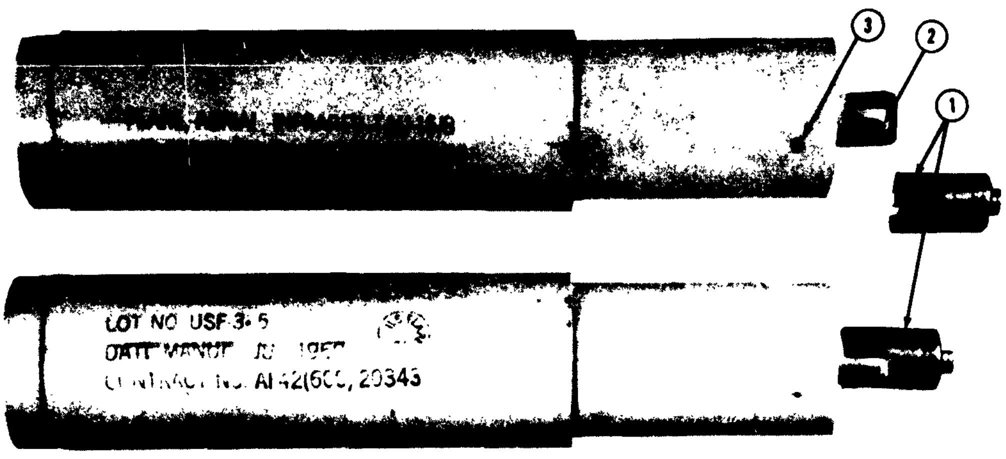

Fig. 2: TAU-15/B Flares with Electrical Shunting Caps: (1) Shunting Caps, (2) Projection for Aligning and Retaining Flare in Flare Holder Socket, (3) Hollow Locking Pin.

3. Internal resistance - less than 0.25 ohm.

4. Recommended firing current - 5.0 amperes.

The flares were received from Ogden Air Materiel Area in individual cartons which were packaged 25 to each larger corrugated paper box. Each flare was equipped with a steel and brass electrical shunting cap installed on the electrical connector (Fig. 2). The shunting cap short circuits the flare ignition system and prevents accidental ignition of the flare by stray electromagnetic radiations. The shunting cap is removed and discarded before the flare is inserted in the target flare holder.

SECTION 3 - TEST INSTRUMENTATION AND PROCEDURES

GROUND TESTS

Sample flares from various production lots were subjected to ground tests in the APGC Armament Strato Chamber. This chamber is capable of providing temperatures from -65°F to 400°F and simulated altitudes from sea level to 60,000 ft. For this test, the flares were examined under cold-soak and ambient temperature conditions at sea level and at a simulated altitude of 35,000 ft.

Upon receipt, the flares were removed from their packing cartons and examined for general condition. No attempts were made to correct any apparent discrepancies prior to the first firing attempts; however, pertinent notes were made of the appearance of the individual flares. Those flares which were cold soaked were placed in one of the large corrugated shipping boxes and left in the chamber overnight while the temperature of the chamber was reduced to -65°F. The flares were then allowed to soak at that temperature for a minimum of 4 hours. The shunting cap was left on each flare until just before the flare was inserted in the flare holder for testing.

A flare-holding rack (Fig. 3) was locally manufactured for use in the chamber. As shown in the figure, five clusters of four flare holders each were positioned 12 in. apart on the rack. This arrangement proved unsatisfactory, however, in that adjacent flares were ignited or otherwise damaged by the heat generated by the first flare burned in each cluster, thus permitting use of only one flare holder in each cluster. Since this arrangement permitted investigation of only five flares during

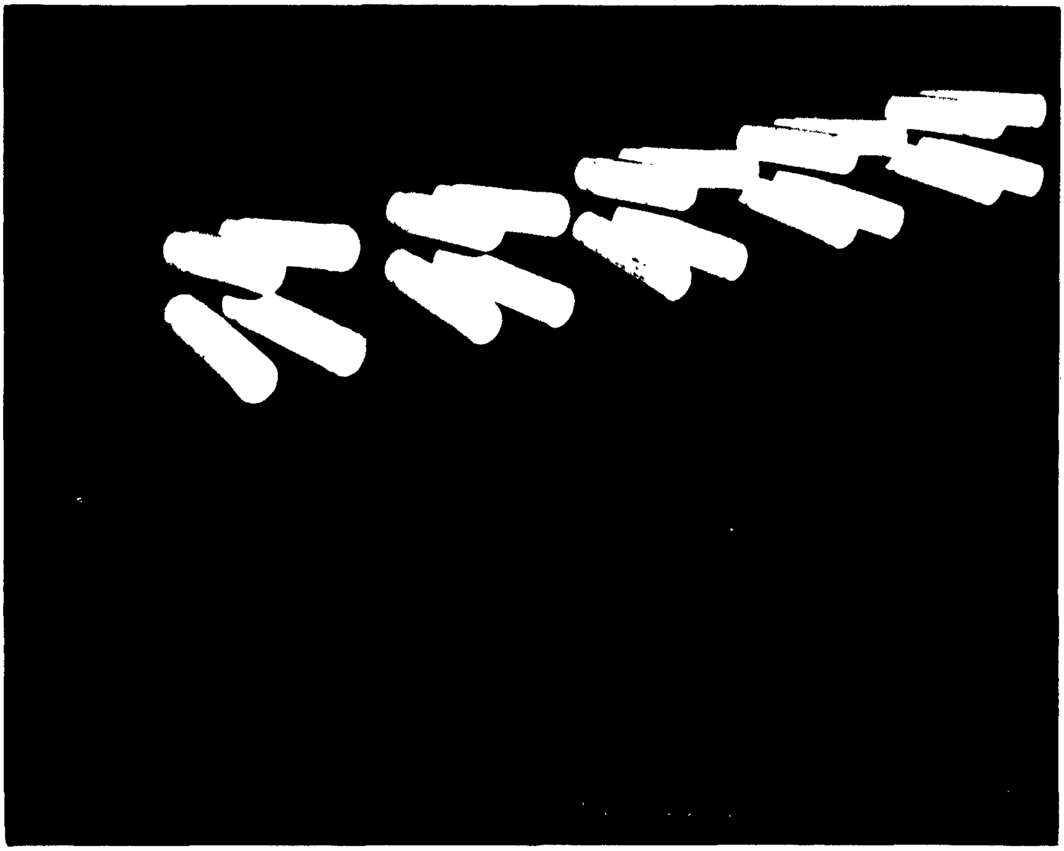

Fig. 3: Original Flare Test Rack with Flares Installed.

any chamber run, the original rack was modified to the configuration shown in Fig. 4 and another similar rack was fabricated. This setup was used in the remaining tests, with a maximum of 12 flares being investigated during each chamber run.

The flare ignition voltage, regulated to 28 vdc, was supplied by either a Westinghouse Silverstat Regulator or a locally manufactured rectifier and was routed through a flare ignition control panel (Fig. 5) to each flare holder. The flare ignition control panel was located outside of the chamber and permitted the flares to be burned individually.

Approximately 40 flares from each production lot (see Table 1, Section 4) were tested in the chamber at each of the four environmental conditions mentioned earlier. Each run of approximately 12 flares required less than 20 min when the chamber was at sea-level pressure

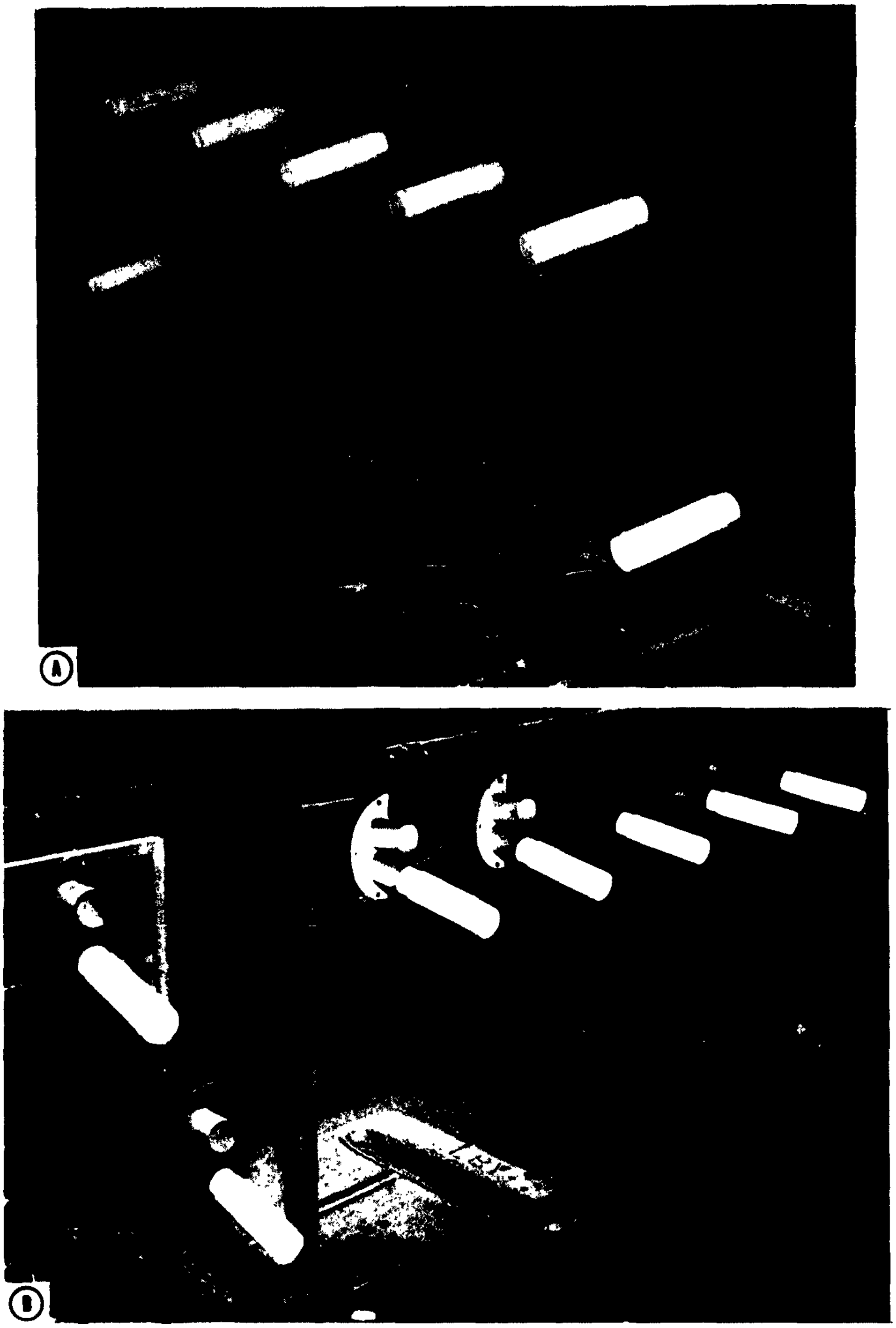

Fig. 4: Modified Flare Test Rack Arrangement: (A) Modified Rack, (B) Right End of Modified Rack and Adjacent New Rack.

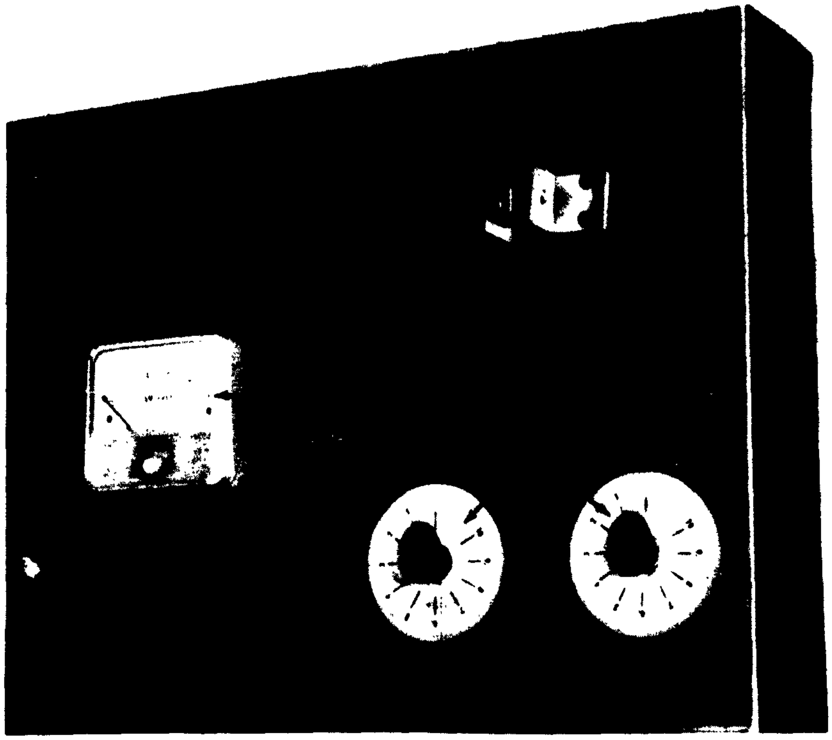

Fig. 5: Flare Ignition Control Panel: (1) Ignition Switch, (2) Flare Selector Switches, (3) D-C Ammeter.

and less than 35 min when the chamber was at 35,000-ft pressure. The pressure was maintained constant during each run but the chamber temperature was not controlled since the heat generated by the burning flares exceeded the cooling capacity of the chamber. Thus the chamber temperature was as high as 125°F at the end of a series of four or five runs during a test period. When cold-soaked flares were being tested, the previously cooled flares were kept insulated until they were installed in the chamber. Some cold flares were exposed to approximately 20 min of warming but most were burned within 9 min after being removed from insulation. The extensive delay between removal of the flares from insulation and burning was usually caused by either flare malfunction or electrical power difficulties in the chamber.

The ignition and burning characteristics of each flare were noted while watching the flares through observation ports in the altitude chamber. Burning time was recorded with a 10-sec-sweep stop watch. The paint and casings of the flares tested in the chamber continued to

burn without force after the main illuminant had been consumed; however, the burning times recorded included only the period from squib firing to the apparent depletion of the main illuminant. Smoke in the chamber often obscured the flares and made determination of the exact instant of illuminant depletion difficult; however, the data are considered accurate to ±1 sec.

AIRBORNE TESTS

In order to determine correlation in flare behavior under simulated and actual conditions, flares from one lot (Lot 3-17) were also investigated during flight at 35,000 ft and mach 0.7. Four flares were installed on each of two TDU-4/B or DF-41R1A* tow targets (Fig. 6) which were towed at approximately 500-ft tow length by a B-57E equipped with AF/A37Z-1 External Tow Target Systems. An observer in a T-33 flying formation on the target(s) recorded the flare ignition and burning characteristics. All flares used in this phase were merely drawn from supply and test flown. None of the flares were cold soaked before flight.

Each flare was examined as during the ground tests before being installed in the targets. The targets and their control receivers were preflighted before each mission as specified in T.O. 43E11-12-1.

Upon reaching test altitude and airspeed, the B-57E pilot launched one target. On prearranged signals from the observer in the T-33, the B-57E pilot switched to the flare ignition frequency and commanded individual ignition of each flare. When ignition of the four flares had been attempted, the first target was recovered and the procedures above were repeated with the remaining target.

The fireball from the flares burned in flight was not obscured by smoke nor was there any apparent afterburning when the main illuminant had been consumed. Nevertheless, burning time data obtained during this phase are considered valid to only ±1 sec since it was difficult to determine exactly when the ignition signal was received by the flares and when the flares stopped burning.

At mission completion, any unburned flares and the targets were inspected to determine the reasons for any malfunction that might have occurred.

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* Nonstandard target.

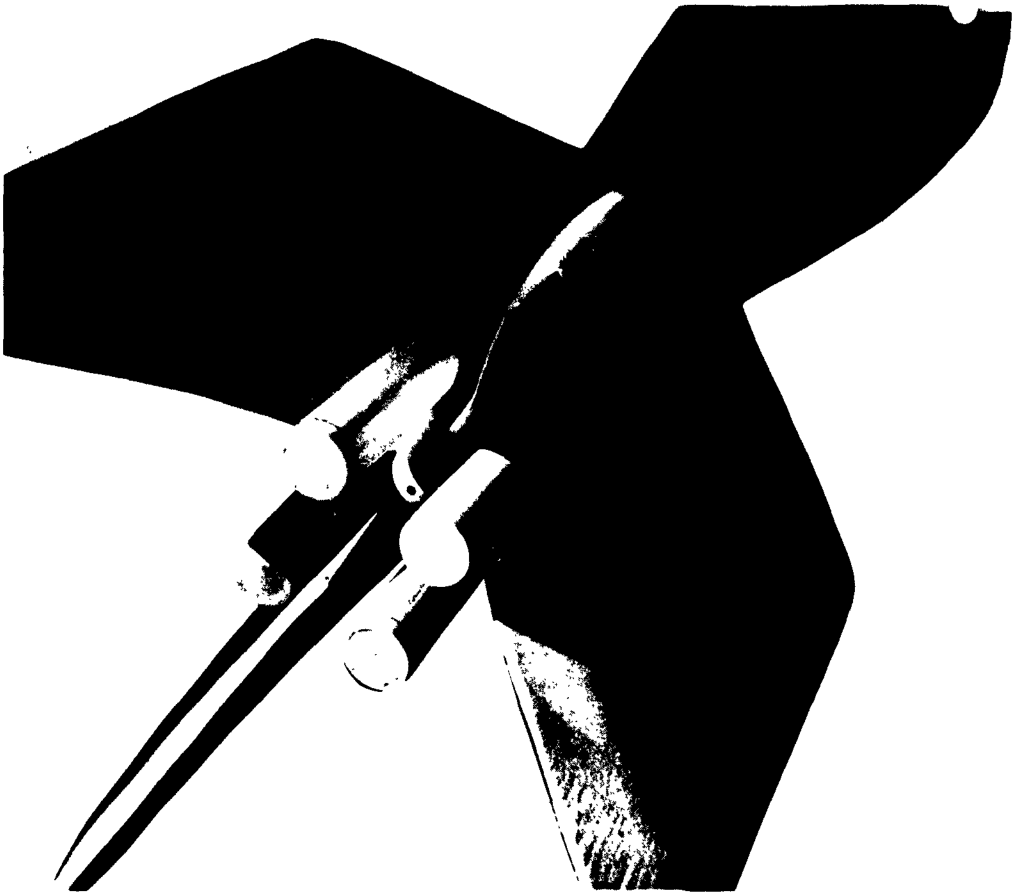

Fig. 6: TAU-15/B Flares Installed on TDU-4/B Tow Target.

SECTION 4 - TEST RESULTS AND DISCUSSION

Many ignition and burning characteristics of the TAU-15/B flares were observed during the tests in the altitude chamber. Complete data on these tests are included in Appendix I. Because of the increased observation range, the dynamic nature of the test platforms, and the operational loss of several targets, not as many characteristics were noted during the airborne tests at 35,000 ft and mach 0.7. All data collected during that phase are presented in Appendix II. Flare performance as derived from the data collected during all testing is summarized in Table 1.

TABLE 1. TAU-15/B FLARE PERFORMANCE SUMMARY.

U.S.F. Lot No.	Test Conditions	No. of Flares Tested	Number of Flares Characterized By:							Average Burning Time (sec)
			Normal Burning and Ignition	Leaking Wax (See Fig. 7.)	Delay Between Squib Firing and Flare Illumination: Momentary	Delay Between Squib Firing and Flare Illumination: 1- to 3-Sec	Abnormal Plume (See Fig. 16.)	Closure Plug Blew Off - No Burning (See Fig. 12.)	Illuminant Blew Out of Case (See Fig. 13.)	
3-1	Altitude Chamber, Sea Level, Ambient Temperature	43	39	8	0	1	2	1	0	83
3-5		40	40	8	0	0	0	0	0	80
3-10		40	40	13	0	0	0	0	0	80
3-17		40	38	7	0	0	2	0	0	79
3-1	Altitude Chamber, Sea Level, 4-hr Cold Soak at -65°F	38	36	7	0	1	0	1	0	87
3-5		40	36	2	0	0	1	0	3	84
3-10		40	24	7	0	0	0	0	16	85
3-17		40	33	16	0	1	0	0	6	83
3-1	Altitude Chamber, 35,000 ft, Ambient Temperature	38	17	4	0	6	1	14	0	178
3-5		40	17	11	5	15	1	2	0	163
3-10		40	28	7	8	3	0	1	0	152
3-17		40	24	5	4	8	1	3	0	159
3-1	Altitude Chamber, 35,000 ft, 4-hr Cold Soak at -65°F	40	18	11	0	6	0	15	1	182
3-5		40*	18	10	0	13	2	2	4	164
3-10		40	15	4	5	9	0	2	6**	165
3-17		40	21	15	6	11	0	2	0	164
3-17	Airborne, 35,000 ft, mach 0.7	28***	19	7	1	1	2	2	0	168
	Totals	667	463	142	29	75	12	45	36	

* Includes flare which would not fit holder. (See Item 3, Fig. 9.)
** Six definitely; three others undetermined.
*** Thirty-six other flares were flown but faults other than those attributable to the flares prevented collection of useful data from those flares.

NOTES: 1. Refer to Appendices I and II for detailed data.
2. Refer to Table 2, p. 22, for data on the approximate age of the flares on the dates they were tested.

Appendix III contains data collected on eight flares of Lot 3-1 during another program (Test of the F-101A Tow Subsystem, APGC Project 6828W2). Appendix IV contains additional data on flares from Lot 3-5. These data were extracted from U.S. Naval Ammunition Depot report RDTR No. 28, TAU-15/B IR Tracking Flare, dated 31 July 1962.

FLARE CONSTRUCTION AND PACKAGING

BAYONET CONNECTORS. Difficulties were experienced with the alignment projections on the flare bayonet connectors (Item 2, Fig. 2) during both the ground and airborne tests. The projections were too small and too soft and were easily damaged during insertion of the flares in the flare holders. As a result, when the projections were damaged, there was no physical way of determining whether the flare electrical contact points were positively aligned with the points in the flare-holder sockets. Consequently, ignition could not be assured. Several misfires in the altitude chamber were attributed to this condition. For test purposes in the chamber the problem was rectified by repositioning the flares which would not ignite and attempting a second or third ignition. Obviously this procedure could not be used during the airborne tests and only flares providing reasonable assurance of proper alignment were flown. Use of strong metal alignment pins of sufficient length should prevent similar difficulties with future similar flares.

LEAKING WAX. Of 667 flares used during this test, 142 (approximately 21%) were characterized by the presence of various amounts of a clear, sticky substance on the forward portions of the cases. Samples of the substance were collected, chemically analyzed, and determined to be wax. KEL-F-40X wax is a constituent of the main illuminant. Examination of the data revealed that flares thus characterized did not ignite or burn any differently than flares without wax deposits. However, the presence of the wax was troublesome. Frequently, the wax had accumulated under and around the shunting caps, requiring the use of pliers to remove the caps. At other times one or both electrical contacts of the flares were covered with the wax. Flares in this condition were experimentally inserted in the flare holders to determine whether it was necessary to clean the contacts in order to obtain ignition. Invariably the presence of the wax on the contacts prevented ignition. Careful scraping was then required to remove the wax from the electrical contacts. In addition, the presence of the wax made handling of the flares unpleasant.

Fig. 7 shows evidence of leaking wax. In the flare shown the wax appeared to be seeping from the space between the phenolic base plug

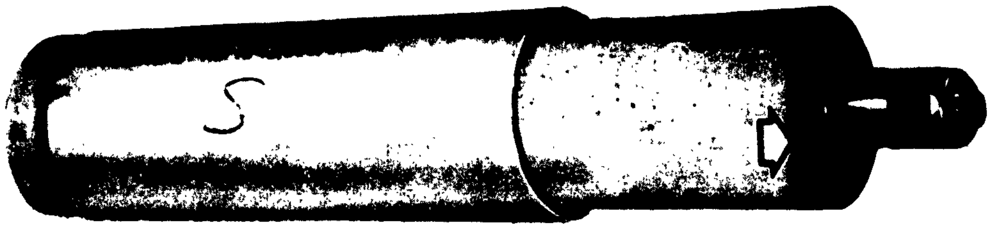

Fig. 7: TAU-15/B Flare Showing Wax Deposits on Phenolic Base Plug and Case of Flare.

and the flare case. Note that the wax has deteriorated the paint. Most frequently the wax was found to be leaking from and around the hollow locking pin in the phenolic base plug of the flare. Fig. 8 shows two flare cartons which had contained flares from which wax had leaked and caused the stains shown.

As indicated in Table 1, this condition did not vary significantly among the four production lots. The condition existed in approximately 19% of the flares in Lots 3-1, 3-5, and 3-10 and in approximately 27% of the flares in Lot 3-17.

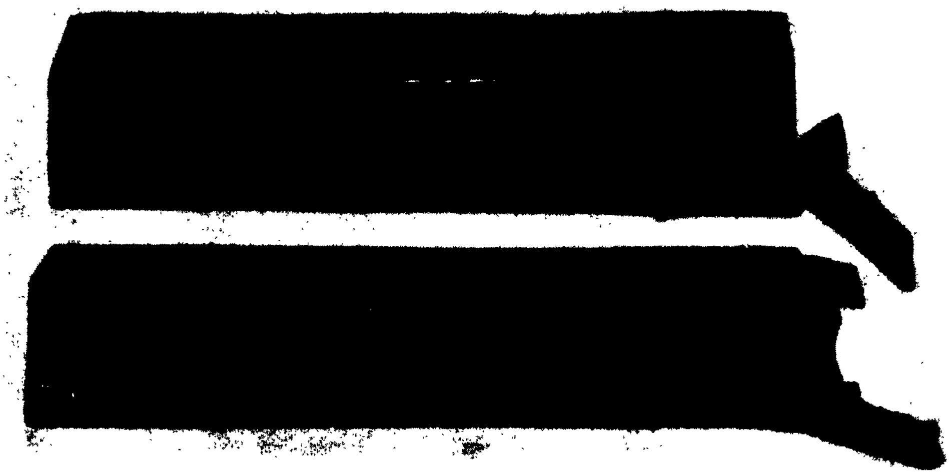

Fig. 8: Flare Packing Cartons Showing Stains Caused by Wax which Leaked from Flares.

ASSEMBLY AND FABRICATION OF OUTER JACKET. The outer metal jackets on three flares from Lot 3-5 were improperly positioned (Fig. 9). It can be seen in the figure that the misalignment on two of the flares occurred after the flares had been painted. When the flares were unpacked, the glue used to hold the metal jackets had dried and they were firmly fixed in position. It appears probable that the glue had not yet set when the flares were packaged at the factory and that the outer jackets slipped out of position when the flares were inserted in the packing cartons. One jacket (Item 3, Fig. 9) had slipped so far forward that the flare could not be inserted in the flare holders used in the chamber. That flare was not tested. The discrepancy would not have prevented use of the flare in a flare holder of the type utilized on the TDU-6/B target but would have prevented its use on targets such as the TDU-9/B. The other two flares (Items 1 and 2, Fig. 9) did not burn properly in the altitude chamber; however, in neither case was the poor performance attributable to the jackets.

During the ground tests small solidified deposits of molten metal were frequently found on the altitude chamber floor under burned flares (Fig. 10). Three samples of the metal were chemically analyzed and determined to be aluminum. It was subsequently determined that the deposits were attributable to melting of the outer jackets of certain flares during the burning operation. Although the manufacturer's literature on the TAU-15/B flares indicates that the flares are equipped with outer jackets made of steel, the flares producing the metallic deposits were found to have jackets made of aluminum. Several unburned flares from each of the production lots were inspected and it was determined that they also were equipped with aluminum outer jackets. Aside from the metallic deposits produced, the flares with the aluminum outer jackets performed normally. No flares recovered from the airborne tests exhibited deterioration of the jackets.

CLOSURE PLUG DEFORMATION. The potting compound used on the flare closure plugs was usually found to be hard and smooth; however, the closure plug of one flare from Lot 3-5 (Item 1, Fig. 11) had been badly deformed by contact with the carton in which the flare had been packed. The closure plug of another flare from the same lot (Item 2, Fig. 11) was also deformed and so soft that it could be marked by the thumbnail. Both of these flares were tested in the altitude chamber at simulated 35,000-ft altitude, with one having been cold soaked prior to having been placed in the chamber. The flare that had not been cold soaked burned normally, but the closure plug of the other flare separated only partially from the flare body at ignition, resulting in an abnormal plume during flare burning.

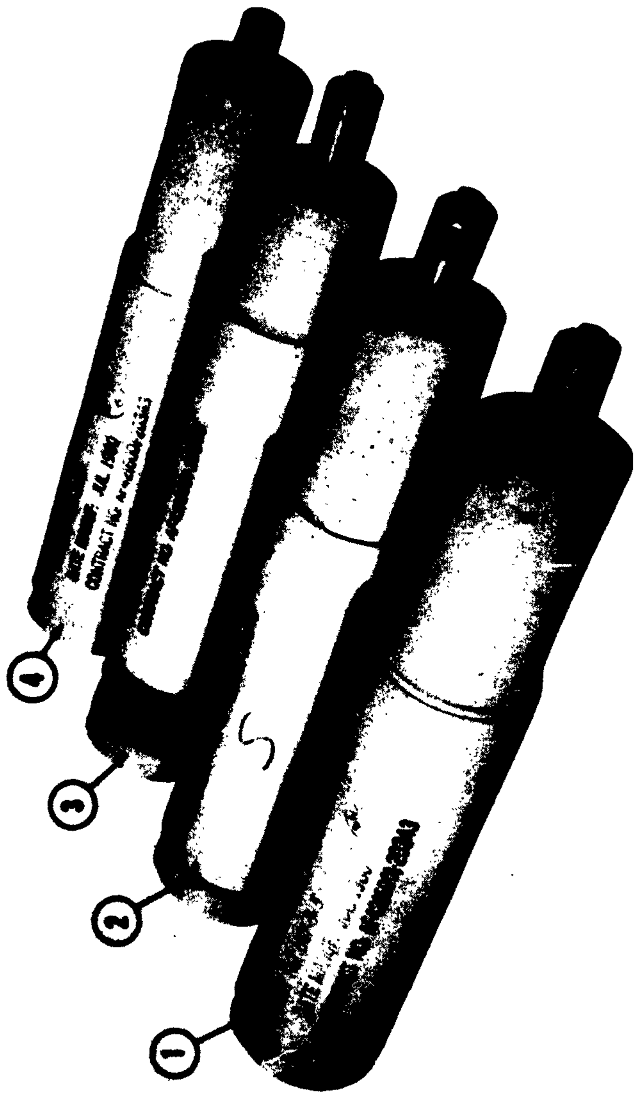

Fig. 9: TAU-15/B Flares Showing Improper Positioning of Outer Jackets: (1) Flare with Jacket Positioned Too Far Aft, (2) and (3) Flares with Jackets Positioned Too Far Forward, (4) Flare with Properly Positioned Jacket Shown for Comparison.

Fig. 10: Aluminum Samples Recovered from Floor of Altitude Chamber.

ELECTRICAL SHUNTING CAPS. Three flares of Lot 3-5 were not equipped with electrical shunting caps (Item 1, Fig. 2) when they were unpacked from their individual cartons. The caps were not found loose in the cartons and obviously had not been installed when the flares were packaged at the factory.

PACKAGING IDENTIFICATION. In addition to other markings, the large corrugated boxes containing U.S.F. Lot 3-1 flares were improperly marked "USF Lot 1;" however, the individual cartons inside these boxes were marked properly as shown in Fig. 8.

ILLUMINATION DELAYS AND FAILURES

ILLUMINATION DELAYS. Table 1 shows that there were often delays between squib firing and illumination of the flares. The data in Appendices I and II indicate that the delays were momentary (nominal) or approximately 1, 2, or 3 sec in duration. In the altitude chamber it was observed that the delays were often accompanied by varying degrees of sputtering inside the aft end of the flares. With the exception

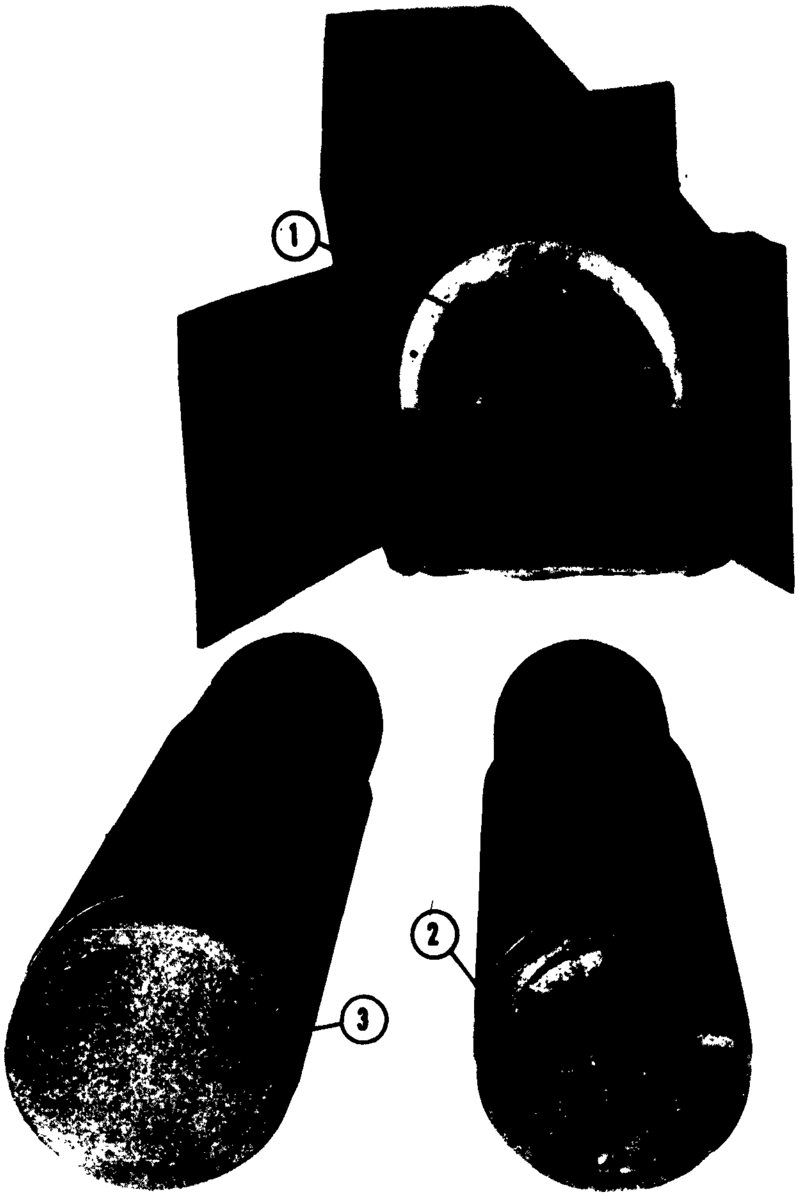

Fig. 11: Flares from Lot 3-5 Showing Condition of Closure Plugs: (1) Closure Plug Deformed by Contact with Packing Carton, (2) Soft Closure Plug (Marked by Thumbnail), (3) Closure Plug of Normal Smoothness and Hardness.

of some of the flares that exhibited sputtering, all flares in which there were delays between squib firing and flare illumination burned satisfactorily. The longer delays observed in the altitude chamber raised doubts that the same flares would have eventually illuminated satisfactorily if they had been subjected to the extinguishing influence of the airflow in the airborne environment. Examination of Table 1 shows that the delays occurred predominantly at simulated altitude rather than at sea level.

ILLUMINATION FAILURES. In 45 of the flares tested in the altitude chamber and during flight, the first fire composition and main illuminant failed to ignite after successful firing of the squibs. (See Fig. 12.) Thirty-one of such flares were from Lot 3-1. The data show that this characteristic is dependent on altitude and pressure as flares tested at sea-level conditions (other than two from Lot 3-1) did not exhibit this poor performance. Generally, these failures were instantaneous at squib firing; however, examination of Appendix I shows that seven flares sputtered momentarily before failing to burn after the squibs had fired and blown off the closure plugs. These instances raise even more doubt about the possible airborne performance of those flares already mentioned under "Illumination Delays."

BURNING CHARACTERISTICS

Cold-soaking the flares at -65°F for 4 hours caused them to burn approximately 4 sec longer than flares burned at ambient temperatures.

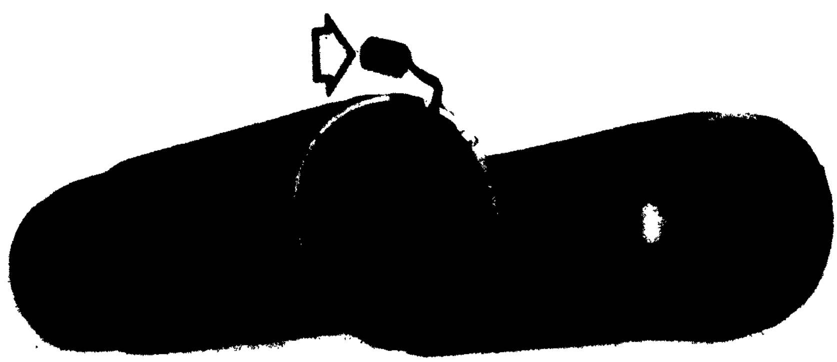

Fig. 12: Typical Flares in which Squibs Fired and Blew Closure Plugs Off but Did Not Ignite First Fire Composition or Main Illuminant. (Arrows point to fired squibs.)

It also caused failures typified in Fig. 13. Thirty-six cold-soaked flares (22 of which were from Lot 3-10) literally exploded at squib firing. The explosions were of different intensities and character. (See Appendix I.) Sometimes only part of the illuminant blew out of the case and burned on the chamber floor while the remaining illuminant burned in the flare case. At other times all the illuminant blew out and burned on the chamber floor. Several times the cylinder of illuminant blew across the chamber and imbedded itself in the chamber wall, setting fire to the chamber wall insulation. As indicated in Fig. 13, the first fire composition and main illuminant sometimes exploded from the cases and did not burn at all. All failures during this test occurred simultaneously with squib firing and no flares exploded after burning for a short period as did some listed in Appendix IV.

The explosions were always very forceful and generally disrupted testing procedures by damaging the test setup in the altitude chamber. Spring-loaded contact points in the flare-holder sockets were often broken off by the shock. The base plates of two flare holders (Fig. 4) were bent beyond further use. The shock sometimes broke the welds holding the racks in an upright position and knocked the racks over. Illuminant burning on the chamber floor burned the ignition wiring and delayed testing while repairs were made.

The exact cause of the explosions was not determined. However, it is believed that uneven contraction of the flare cases and illuminant during cold soak provided space for the expanding gases created by squib firing and subsequent burning of the loose ignition composition to travel to the base of the flare before the closure plugs separated from the flare body. Thus the illuminant was forced out of the cases when the plugs blew off. In one instance the main illuminant did not blow out of a cold-soaked flare after squib ignition and separation of the closure plug from the flare case (Fig. 14). As shown in the figure there was obvious contraction of the main illuminant, thus supporting the hypothesis indicated above. As this flare warmed at room temperature, no noticeable expansion of the illuminant occurred during a 2- to 3-hour period.

A 4-hour cold soak at -65°F is considered to be too severe a test of the operational performance of the TAU-15/B flares since these flares would not normally be subjected to such an environment when employed operationally. A 2-hour cold soak would more realistically simulate operational conditions; however, it is felt that acceptance tests of these and similar flares could logically include the more stringent tests to assure operationally suitable items.

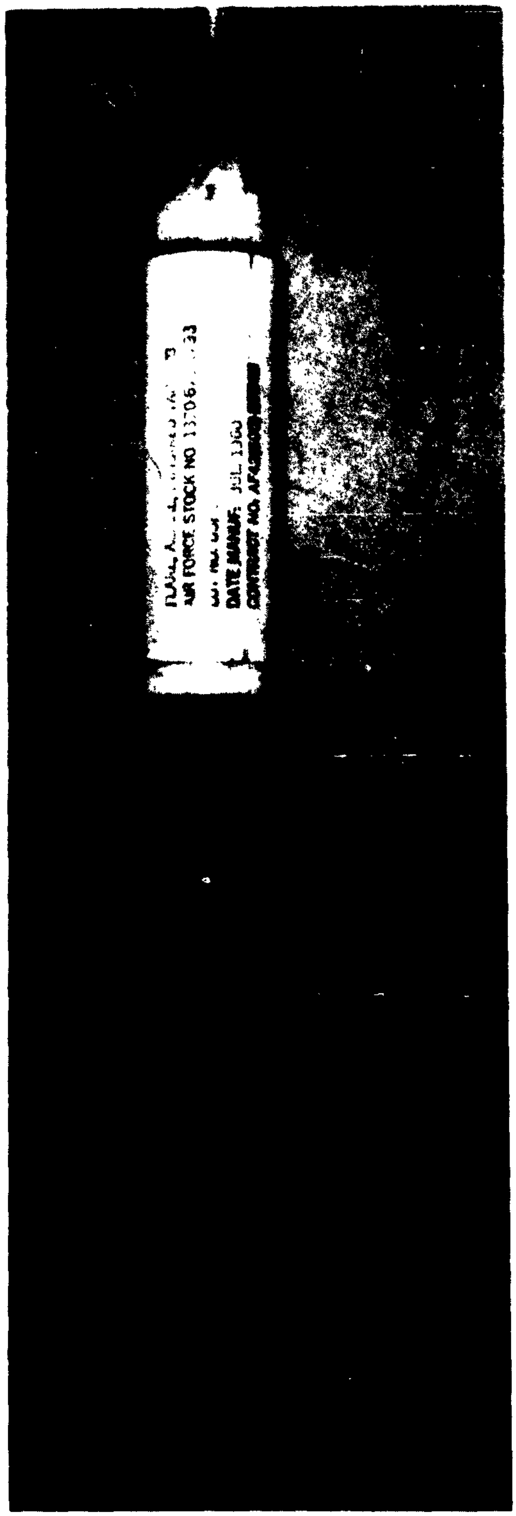

Fig. 13: Typical Empty Flare Case and Cylinder of First Fire Composition and Main Illuminant which Was Blown Onto Floor of Altitude Chamber when Squib Fired.

Fig. 14: Lot 3-10 Cold-Soaked Flare with Blown Closure Plug. (Note that the main illuminant has contracted from the walls of the case.)

Three flares of Lot 3-10 performed in an exceptional manner at a simulated altitude of 35,000 ft after having been cold soaked. Squib firing was accompanied by the loud explosive noise which usually occurs when the main illuminant is blown out of the flare case. However, no such occurrence was observed in those instances. The flares burned for 123, 67, and 83 sec. Other Lot 3-10 flares burned an average of 165 sec under the same test conditions. Examination of the three cases showed that all of the illuminant had been consumed.

Flares tested at sea level, which burned for approximately 80 sec (see Table 1), did not burn through the flare casing at the narrow diameter (Fig. 15). In fact, many of these flares retained enough rigidity after burning to be salvaged for use as ballast loads during flight tests of TDU-6/B targets. However, flares tested at 35,000 ft, which burned for approximately 160 sec (see Table 1), normally burned through the casing, causing the portion with the metal outer jacket to fall off at the end of burning or to twist off upon removal of the flare from the flare holder. Part of only one of the recovered flares broke off during the flight tests because of this characteristic. Nevertheless, portions of the flares may be expected to fall off in flight or perhaps during landings. Consequently, using organizations should be alert for possible cluttering of airspace below towed flares or of runways after tow aircraft have landed.

When the flares were burned in the altitude chamber at sea level, normal flare plumes appeared to be approximately 1 1/4 to 1 1/2 times the length of the flares and of slightly larger diameter. At 35,000 ft in the chamber the plumes appeared to be approximately twice as long as the flares during the first part of burning. In all cases the diameter of the plumes gradually increased and their length gradually decreased as the flares burned. No burned flare cases were found in which all the illuminant had not been consumed.

Fig. 15: TAU-15/B Flare Cases After Burning of the Flares at (1) Sea Level and (2) 35,000 ft Altitude.

Twelve flares from all of the lots presented abnormal plumes. In each case this was experienced when the closure plug separated only partially when the squib was fired. Consequently, the flare plume was forced out a relatively narrow space at an angle to the flare rather than through the approximately 1 1/4-in.-diameter flare end and in line with the flare. When abnormal plumes occurred the flares sometimes burned with more smoke than normal and the burning times were erratic. The burning times of these flares were not used in computing average burning times. Fig. 16 shows two of the flares which produced abnormal plumes.

SHELF-LIFE CONSIDERATIONS

Before the tests began, it was thought that flare age might influence flare performance. Consequently, data concerning flare age were collected and are shown in Table 2. The poorest performing flares (Lot 3-1) were 25 to 26 months old and the best performing flares (Lot 3-17) were 24 to 25 months old. The next best flares (Lot 3-5) were 31 months old and the third best (Lot 3-10) were 29 to 30 months old. The Lot 3-5 flares tested by the Navy (see Appendix IV) were 20 months old. All flares tested at Eglin AFB were stored in the same warehouse without temperature or humidity control. It should be noted that Lot 3-1 flares were stored at Eglin AFB for approximately 24 months

Fig. 16: Three Flares After Burning at Sea Level Without Prior Cold Soak: (1) Normal Condition (Flare Burned 90 sec), (2) Closure Plug Loosened on One Side, Causing Irregular Plume (Flare Burned 89 sec), (3) Closure Plug Loosened on One Side, Causing Very Bright, Irregular Plume (Flare Burned 89 sec).

TABLE 2. FLARE AGE DATA.

U.S.F. Lot No.	Date of Manufacture	Date of Arrival at Eglin AFB	Date Tested	Approximate Age on Date Tested
3-1	Jul 60	7 Sep 60	Aug-Sep 62	25-26 months
3-5	Jul 60	8 Feb 63	Feb 63	31 months
3-10	Sep 60	8 Feb 63	Feb-Mar 63	29-30 months
3-17	Oct 60	11 Sep 62	Oct-Nov 62	24-25 months

while the other three lots were stored at Ogden Air Materiel Area prior to shipment to Eglin for testing. These latter three lots were exposed to Eglin's climate for no longer than two months before being tested. It can only be concluded that flare age was not a significant factor in the variation in flare performance among lots and that the shelf life of the TAU-15/B flares was not determined.

TECHNICAL DATA

No technical order covering the usage, storage, and handling of TAU-15/B flares has been published. The lack of such technical data restricted efficient performance by the personnel charged with loading, towing, and downloading the flares during the airborne tests. Inexperienced operators in the using commands are expected to be equally hindered.

SUMMARY AND ANALYSIS

As indicated in Table 1, Lot 3-1 flares were tested only in the altitude chamber. Because of the poor performance of these flares at simulated altitude in the altitude chamber (see Table 1) and during flights on another program (see Appendix III), no attempts were made to flight test flares from that lot. Flares of Lot 3-17 performed significantly better in the altitude chamber at simulated altitude. As a result, other flares from Lot 3-17 were flight tested at 35,000 ft and mach 0.7 to determine whether airborne data would correlate with the data collected in the altitude chamber. Shown in Table 3 is a comparison of the more significant characteristics of flares from this lot at a simulated and actual altitude of 35,000 ft. It was concluded from the comparison that tests of unconditioned flares at 35,000 ft in the altitude chamber simulated 1- to 2-hour flight conditions at 35,000 ft and mach 0.7 reasonably well. Based on this reasoning, no other flares from the remaining lots were flight tested.

In comparing the relative performance of the different lots tested, the following characteristics shown in Table 1 are ignored:

1. Leaking wax, because it was determined that that characteristic did not affect flare burning and because each lot showed approximately the same percentage of flares with leaking wax.

2. Delay between squib firing and flare illumination, because it is felt that that characteristic did not affect flare burning once the main illuminant finally ignited.

The results obtained in the altitude chamber at sea level and ambient temperature conditions as compared with those obtained at altitude in the chamber and in flight indicate that the tests at ambient conditions were of limited value. They did not correlate with results obtained under the other environmental conditions. Since operational employment of the TAU-15/B flares at sea level is considered highly unlikely, and because

TABLE 3. PERFORMANCE OF LOT 3-17 FLARES TESTED IN THE ALTITUDE CHAMBER AND IN FLIGHT AT 35,000 FT ALTITUDE.

Conditions	Number Tested	Number/Percent with Abnormal Plumes	Number/Percent in Which No Burning Occurred After Squib Ignition and Separation of Closure Plug	Average Burning Time (sec)
Altitude Chamber (Not Cold Soaked)	40	1/2.50	3/7.50	159
Airborne, Mach 0.7	28	2/7.15	2/7.15	168
Altitude Chamber (Cold Soaked)	40	0/0	2/5.00	164

of the preceding conclusion, it is felt that similar future tests of TAU-15/B and substitute flares would not be useful in predicting operational behavior.

Tests under cold-soak conditions at sea level might also be considered of limited value except that they did foretell flare failures (explosions) under cold-soak conditions at altitude. The cold-soak tests versus the ambient temperature tests indicate that since the flares are temperature sensitive they should be protected from extreme cold prior to use, and that failures may be expected during operational employment if tow aircraft remain at high altitude more than approximately 2 hours before firing of the flares.

Twelve of 667 flares produced abnormal plumes because the closure plugs did not completely separate from the flare bodies upon firing of the squibs. These abnormal plumes were distributed rather evenly over the four test conditions and three of the four flare lots. Percentages by lot were: Lot 3-1, 1.9%; Lot 3-5, 2.5%; Lot 3-10, 0%; and Lot 3-17, 2.8%. It was not determined in this test whether or not the abnormal plumes should be considered failures. Perhaps the 12 flares referenced above produced sufficient radiation that they would have satisfied the requirements for an operational mission.

Except for Lot 3-1 flares, the average burning times of all of the

flares tested did not seem to vary excessively at each test condition. The average burning time for Lot 3-1 flares was noticeably (2 to 19 sec) longer in each case. No explanation is submitted and this characteristic is not used as a basis for comparing the different lots.

The preceding discussion reduces the comparison of the different lots to an examination of the characteristic of the flares to fail to burn after squib ignition and separation of the closure plug. Flares of any given lot produced nearly the same number of this kind of failure at altitude whether or not they had been cold soaked. The failure occurred only twice at sea level. The reason for these failures is not known. It appears that the difficulty may lie with one or more of the components of the ignition system (closure plug, squib, ignition composition, and first fire composition).

Although the following possibilities are not supported by test data they are offered for consideration. If the closure plug were too weak and came off too easily under reduced pressure, the loose ignition composition might not be retained long enough to ignite the first fire composition and subsequently ignite the main illuminant. It might also be that the first fire composition is not easily enough ignited or that it does not presently have enough surface exposed to the loose ignition material. Another possibility is that during storage of the flares some KEL-F-40X wax may have seeped from the main illuminant to the first fire composition. The presence of wax on the exterior of approximately 21% of the flares tested supports this hypothesis. If sufficient wax were to seep to the aft surface of the first fire composition, it could effectively isolate the loose ignition composition and delay or prevent ignition of the flare. Laboratory analysis of the aft surface of the first fire composition contained in a Lot 3-1 flare which failed in this manner disclosed a large wax content. The sputtering noted during the excessive delays in illumination support all three hypotheses to a limited degree.

Returning to Table 1, it is noted that there were an excessive number of burning failures (37.2%) at altitude for Lot 3-1 flares. Similar failures for other flares under the same conditions were: Lot 3-5, 5%; Lot 3-10, 3.8%; and Lot 3-17, 6.5%. Based on these percentages the tendency is to grade the lots, from fair to unacceptable, in the following order: Lot 3-10, Lot 3-5, Lot 3-17, Lot 3-1. However, the severe temperature sensitivity of the Lot 3-10 flares and the somewhat less sensitivity of the Lot 3-5 flares make it necessary to revise the order so that:

1. Lot 3-17 flares should be used before flares in the other lots tested.

2. Lot 3-5 flares should be expected to give the next best performance.

3. Lot 3-10 flares should be expected to give very marginal performance.

4. Lot 3-1 flares should not be flown operationally.

It was not observed during this test that flare age was a significant factor in the variation in flare performance among lots.

SECTION 5 - CONCLUSIONS

It is concluded that:

1. The TAU-15/B flare ignition failure rate varies from one flare production lot to another and with the altitude at which the flares are used and the internal temperature of the flares. Specifically, although the flares burn approximately twice as long at 35,000 ft as at sea level, the ignition system (squib, closure plug, and ignition and first fire composition) of these flares does not perform reliably at high altitudes. In addition, the performance of the flares is degraded by extreme low internal temperature.

2. Based on the performance of the flare lots tested, the following judgments concerning flare ignition characteristics are made regarding these lots of flares:

a. U.S.F. Lot 3-17 TAU-15/B flares performed better than flares from other lots tested.

b. U.S.F. Lot 3-10 and Lot 3-5 TAU-15/B flares may be expected to perform in a marginal manner at high altitudes (above 30,000 ft), particularly if flight time at altitude exceeds approximately 2 hours.

c. U.S.F. Lot 3-1 TAU-15/B flares are unsuitable for operational use.

3. Although the useful shelf life of TAU-15/B flares was not determined in this test, flare age was not found to be a significant cause of variation in flare performance in the lots tested. The possible effects

of temperature and humidity conditions during storage could not be determined.

4. The manufacturer's quality inspection procedures appear marginal, as evidenced by improper assembly of the outer metal jackets, closure plug deformation, failure to install shunting caps over the electrical connectors, and improper packaging identification.

5. The wax deposits found on approximately 21% of the flares interfered with flare ignition when the wax was located on the electrical contacts of the flares; however, this condition did not affect the burning performance of these flares.

6. The alignment projections provided on the bayonet-type electrical connectors of the flares are mechanically unsatisfactory.

7. TAU-15/B flare cases burned at altitude present possible foreign object hazards in the airspace below towed targets and on runways after tow aircraft land.

8. The performance of the TAU-15/B flares tested indicates that no further procurement of these flares should be made.

9. The following judgments are made regarding correlation of the test data obtained in the altitude chamber and in flight:

a. Delays between squib firing and flare illumination noted in the altitude chamber might result in flare failures in the airborne environment; however, this test did not substantiate this relationship.

b. Testing non-temperature-conditioned flares in the altitude chamber at 35,000 ft altitude simulated 1- to 2-hour flight conditions at 35,000 ft and mach 0.7 reasonably well.

c. The results of tests at sea-level conditions did not help predict flare performance to be expected under operational conditions.

d. Subjecting the flares to a 4-hour cold soak before test does not realistically simulate a normal operational condition.

SECTION 6 - RECOMMENDATIONS

The Air Proving Ground Center recommends that:	Comments of Detachment 4, Aeronautical Systems Division:
1. All TAU-15/B flares of U.S.F. Lot 3-1 be removed from user and depot inventories.	1. Necessary action has been taken as a result of preliminary test results.
2. U.S.F. Lot 3-17 flares be provided to units having operational requirements for TAU-15/B flares.	2. Necessary action has been taken as a result of preliminary test results.
3. Tests of remaining U.S.F. lots of TAU-15/B flares be conducted at simulated altitude to determine their fitness for operational use.	3. The Ogden Air Materiel Area has requested the Department of the Navy to perform tests on remaining production lots and to determine shelf life.
4. Procurement of additional TAU-15/B flares be avoided and that the TAU-15/B flares be replaced at the earliest possible date. Subsequently, all TAU-15/B flares should be removed from the Air Force inventory.	4. The TAU-50/B infrared flare is being developed. Limited production of this replacement flare will occur during FY 64. Action to procure additional TAU-15/B flares or to remove from inventory existing flares will depend upon the needs of the Air Force.
5. Consideration be given to specifying special storage of these and similar items.	5. Requirements for controlled-environment storage conditions will be reviewed.
6. Particular attention be directed toward design of flare ignition systems to include consideration of squib power, closure plug strength, and ignition and first fire compositions.	6. Design of the ignition system for the TAU-50/B flare differs significantly from the system used in the TAU-15/B flare. Further procurement of the TAU-15/B flare is considered unlikely.
7. Acceptance tests of future similar flares include	7. Complete review of the criteria for acceptance of flares

investigation of ignition performance at simulated altitude after cold soaking.	is necessary.
8. Future flares with bayonet-type electrical connectors be provided with sturdy alignment pins in the connectors rather than the simple projections used on the TAU-15/B flares.	8. Redesign of an electrical connector to increase its strength is necessary for tow target flares.
9. Users be advised of possible foreign object hazards presented by TAU-15/B flares.	9. This information will be forwarded to the Ogden Air Materiel Area for appropriate action.
10. Should these flares remain in Air Force inventory, a technical order be prepared and distributed to provide users with information relative to storage, handling, inspection, and use of TAU-15/B flares. The technical order should include directions to ensure removal of wax from the contact points of the flares.	10. The need for a technical order will depend on usage of the TAU-15/B flare. Removal of the TAU-15/B flare from inventory at an early date is indicated.

APPENDIX I

DETAILED DATA ON U.S.F. LOT 3-1, 3-5, 3-10, AND 3-17 TAU-15/B FLARES TESTED IN ALTITUDE CHAMBER

Included in the following table is a compilation of all data obtained on the ignition and burning characteristics of the U.S.F. Lot 3-1, 3-5, 3-10, and 3-17 TAU-15/B flares during tests conducted in the Armament Strato Chamber at the Air Proving Ground Center. Refer to p. 7 of the main body of the report for a discussion of the accuracy of the burning time data included in Column 6. An explanation of the numerically coded remarks shown in the last column is presented on p. 44.

U.S.F. Lot No.	Date of Test	Chamber Pressure	Flare Temperature Soak	Flare No.	Burning Time (sec)	Remarks (See p. 44.)
3-1	30 Aug 62	Sea level	None	1	85	
				2	80	1
				3	83	
				4	78	
				5	83	
				6	88	
				7	80	
				8	82	
				9	-	8
				10	81	
				11	79	
				12	75	1
				13	85	6
				14	78	
				15	79	1
				16	83	
				17	78	
				18	91	
				19	85	
				20	77	
				21	82	1
				22	78	1
	4 Sep 62			23	86	
	6 Sep 62			24	83	1
				25	80	1
				26	75	1
				27	95	
				28	89	9, 12
				29	94	
				30	93	
				31	91	
				32	89	9, 12
				33	72	
				34	73	
				35	94	
				36	72	
				37	86	
				38	81	
				39	85	
				40	84	
				41	88	
				42	92	
				43	97	
					83	Average Burning Time
3-1	31 Aug 62	Sea level	4 hr at -65°F	1	80	
				2	90	
				3	-	7
				4	75	
				5	80	
				6	85	
				7	97	
				8	87	
				9	92	
				10	78	
				11	85	
				12	92	
				13	95	

U.S.F. Lot No.	Date of Test	Chamber Pressure	Flare Temperature Soak	Flare No.	Burning Time (sec)	Remarks (See p. 44.)
3-1 (Cont'd)	31 Aug 62	Sea level	4 hr at -65°F	14	85 (approx)	12, Power Malfunction
				15	90 (approx)	1, 12, Power Malfunction
				16	89	1
				17	84	
				18	89	
				19	92	1
				20	89	1
				21	91	1
				22	87	
				23	83	
				24	90	
				25	87	
				26	90	
				27	84	
				28	82	
				29	87	6
				30	93	
				31	75	
				32	89	
				33	74	
				34	75	1
				35	94	1
				36	89	
				37	90	
				38	90	
					87	Average Burning Time
3-1	4 Sep 62	35,000 ft	None	1	178	
				2	-	7
				3	-	7
				4	-	7
				5	176	6
				6	174	1
				7	-	1, 7
				8	180	1, 4
				9	179	1, Abnormal Plume for 5 sec
				10	-	7
				11	-	7
				12	180	
				13	168	4
				14	-	7
				15	174	6
				16	187	
				17	175	
				18	181	4
				19	-	8
	5 Sep 62			20	180	
				21	171	
				22	-	7
				23	-	7
				24	183	
				25	188	
				26	185	
				27	172	
				28	-	7
				29	176	

U.S.F. Lot No.	Date of Test	Chamber Pressure	Flare Temperature Soak	Flare No.	Burning Time (sec)	Remarks (See p. 44.)
3-1 (Cont'd)	5 Sep 62	35,000 ft	None	30	187	6
				31	192	
				32	175	
				33	151	
				34	-	7
				35	-	7
				36	183	
				37	186	
				38	-	7
					178	Average Burning Time
3-1	5 Sep 62	35,000 ft	4 hr at -65°F	1	184	
				2	193	
				3	159	
				4	181	
				5	-	8
				6	-	7
				7	-	8
				8	-	7
				9	-	7
				10	198	5
				11	187	
				12	-	7
				13	175	4
				14	-	7
				15	182	5
				16	-	7
				17	173	
				18	177	
				19	-	7
				20	Unk	6, Smoke Obscured Flare
	6 Sep 62			21	170	1
				22	-	1, 10
				23	185	1
				24	195	1
				25	163	1
				26	-	1, 7
				27	174	1
				28	-	1, 7
				29	199	1
				30	181	1
				31	-	1, 7
				32	-	7
				33	179	
				34	183	
				35	193	
				36	182	4
				37	-	7
				38	-	7
				39	187	
				40	184	6
					182	Average Burning Time

U.S.F. Lot No.	Date of Test	Chamber Pressure	Flare Temperature Soak	Flare No.	Burning Time (sec)	Remarks (See p. 44.)
3-5	18 Feb 63	Sea level	None	1	Unk	1, Delayed Start - Test Power Malfunction
				2	82	1
				3	78	1
				4	75	1
				5	83	1
				6	77	1
				7	87	
				8	79	
				9	78	
				10	80	
				11	68	1
				12	69	1
				13	88	
				14	90	
				15	78	
				16	80	
				17	78	
				18	82	
				19	68	
				20	81	
				21	68	
				22	78	
				23	75	
				24	79	
				25	80	
				26	81	
				27	85	
				28	95	
				29	77	
				30	85	
				31	84	
				32	87	
				33	82	
				34	90	
				35	85	
				36	70	
				37	80	
				38	75	
				39	80	
				40	86	
					80	Average Burning Time
3-5	19 Feb 63	Sea level	4 hr at -65°F	1	82	1
				2	60	1, 11, 12
				3	87	
				4	114	12, Flare Burned in Spurts
				5	81	
				6	87	
				7	88	
				8	79	
				9	88	
				10	84	
				11	80	
				12	92	
				13	89	
				14	80	

U.S.F. Lot No.	Date of Test	Chamber Pressure	Flare Temperature Soak	Flare No.	Burning Time (sec)	Remarks (See p. 44.)
3-5 (Cont'd)	19 Feb 63	Sea level	4 hr at -65°F	15	78	
				16	89	
				17	79	
				18	92	
				19	80	
				20	85	
	20 Feb 63			21	Unk	Vapor Obscured Flare
				22	-	10
				23	87	
				24	82	
				25	87	
				26	86	
				27	79	
				28	93	
				29	81	
				30	76	
				31	78	
				32	48	11, 12
				33	86	
				34	91	
				35	84	
				36	89	
				37	86	
				38	80	
				39	85	
				40	77	
					84	Average Burning Time
3-5	19 Feb 63	35,000 ft	None	1	183	Deformed Closure Plug, See Item 1, Fig. 11
				2	169	3
				3	166	
				4	167	4
				5	163	5
				6	165	
				7	159	4
				8	153	5
				9	152	4
				10	168	6
				11	180	1
				12	171	2
				13	165	1, 3
				14	166	1
				15	160	1
				16	170	1, 6
				17	160	1
				18	168	1
				19	161	1
				20	164	2
	20 Feb 63			21	146	
				22	168	
				23	176	6
				24	-	8
				25	150	4
				26	159	4
				27	176	6
				28	162	4

U.S.F. Lot No.	Date of Test	Chamber Pressure	Flare Temperature Soak	Flare No.	Burning Time (sec)	Remarks (See p. 44.)
3-5 (Cont'd)	20 Feb 63	35,000 ft	None	29	132	9, 12
				30	181	
				31	159	3
				32	165	3
				33	158	5
				34	136	4
				35	166	5
				36	-	8
				37	153	
				38	161	2, 3
				39	148	
				40	157	
					163	Average Burning Time
3-5	21 Feb 63	35,000 ft	4 hr at -65°F	1	10	11, 12, Jacket Slipped. See Fig. 9, Item 3.
				2	25	1, 11, 12, Jacket Slipped. See Fig. 9, Item 2.
				3	181	1, 4
				4	-	1, 10
				5	155	1, 5
				6	149	1, 6
				7	162	1, 4
				8	164	1
				9	195	1
				10	-	1, 10
				11	185	4
				12	161	
				13	159	
				14	163	
				15	171	
				16	188	
				17	150	
				18	176	1, 4
				19	172	9, 12, Soft Closure Plug. See Item 2, Fig. 11.
				20	-	7
				21	-	8
				22	173	4
				23	165	
				24	164	4
				25	162	6
				26	164	5
				27	162	
				28	143	4
				29	186	
				30	160	
				31	148	
				32	164	
				33	164	
				34	154	5
				35	200	9, 12
				36	154	
				37	149	
				38	173	4
				39	151	
				40	-	Jacket not properly positioned. Flare would not fit holder. See Item 3, Fig. 9.
					164	Average Burning Time

U.S.F. Lot No.	Date of Test	Chamber Pressure	Flare Temperature Soak	Flare No.	Burning Time (sec)	Remarks (See p. 44.)
3-10	25 Feb 63	Sea level	None	1	87	1
				2	77	1
				3	73	1
				4	75	1
				5	70	1
				6	85	1
				7	80	1
				8	74	1
				9	89	1
				10	77	1
				11	81	1
				12	82	1
				13	85	
				14	83	
				15	81	
				16	75	
				17	84	
				18	74	
				19	84	
				20	73	
				21	77	
				22	82	
				23	87	
				24	82	
				25	81	
				26	79	
				27	82	
				28	81	
				29	81	
				30	77	
				31	81	
				32	75	
				33	85	
				34	72	
				35	80	1
				36	85	
				37	85	
				38	77	
				39	72	
				40	81	
					80	Average Burning Time
3-10	26 Feb 63	Sea level	4 hr at -65°F	1	Unk	Vapor Obscured Flare
				2	77	
				3	-	10
				4	83	
				5	90	
				6	85	
				7	86	
				8	85	
				9	78	
				10	86	
				11	33	11, 12
				12	-	10
				13	92	
				14	-	10
				15	76	
				16	83	

U.S.F. Lot No.	Date of Test	Chamber Pressure	Flare Temperature Soak	Flare No.	Burning Time (sec)	Remarks (See p. 44.)
3-10 (Cont'd)	26 Feb 63	Sea level	4 hr at -65°F	17	91	
				18	-	10
				19	93	
				20	87	
				21	92	1
				22	-	1, 10
				23	81	1
				24	48	2, 11, 12
				25	78	1
				26	18	1, 11, 12
				27	91	1
				28	58	11, 12
				29	88	
				30	89	
				31	-	10
				32	-	10
				33	66	11, 12
				34	86	
				35	78	
				36	-	10
				37	-	10
				38	36	11, 12
				39	-	10
				40	88	
					85	Average Burning Time
3-10	26 Feb 63	35,000 ft	None	1	169	
				2	158	
				3	-	7
				4	160	
				5	143	
				6	140	
				7	157	
				8	145	
				9	143	5
				10	151	
				11	184	
				12	159	
				13	154	
				14	156	
				15	159	
				16	163	3
				17	161	6
				18	154	
				19	148	
				20	146	
	28 Feb 63			21	142	1
				22	162	1, 6
				23	148	1, 3
				24	144	1
				25	144	1
				26	136	1
				27	138	2, 3
				28	150	3
				29	135	3
				30	143	
				31	146	3
				32	141	

U.S.F. Lot No.	Date of Test	Chamber Pressure	Flare Temperature Soak	Flare No.	Burning Time (sec)	Remarks (See p. 44.)
3-10 (Cont'd)	28 Feb 63	35,000 ft	None	33	178	
				34	165	
				35	140	
				36	146	3
				37	152	3
				38	142	
				39	163	
				40	160	
					152	Average Burning Time
3-10	28 Feb 63	35,000 ft	4 hr at -65°F	1	123	11, 12
				2	-	10
				3	67	3, 11, 12
				4	165	
				5	-	10
				6	83	4, 11, 12
				7	-	7, See Fig. 14.
				8	168	4
				9	153	
				10	162	
				11	145	
				12	184	3
				13	159	4
				14	131	
				15	-	10
				16	154	
				17	180	
				18	159	
				19	161	
				20	160	5
	1 Mar 63			21	177	1
				22	155	1, 5
				23	176	1, 4
				24	157	1
				25	-	10
				26	165	
				27	-	10
				28	171	
				29	158	
				30	184	3
				31	166	
				32	166	
				33	194	6
				34	175	4
				35	-	10
				36	180	3
				37	152	
				38	153	4
				39	177	3
				40	-	7
					165	Average Burning Time

U.S.F. Lot No.	Date of Test	Chamber Pressure	Flare Temperature Soak	Flare No.	Burning Time (sec)	Remarks (See p. 44.)
3-17	1 Oct 62	Sea level	None	1	82	
				2	83	
				3	85	
				4	82	
				5	84	
				6	79	9, 12
				7	84	
				8	81	
				9	78	
				10	84	9, 12
				11	81	
				12	81	
				13	84	
				14	79	
				15	84	
				16	79	
				17	83	
				18	76	
				19	76	
				20	76	
				21	75	
				22	80	
				23	80	
				24	78	
				25	79	
				26	74	
				27	80	
				28	79	
				29	79	
				30	78	
				31	78	
				32	76	
				33	83	1
				34	76	1
				35	77	1
				36	76	1
				37	76	1
				38	81	1
				39	77	1
				40	77	
					79	Average Burning Time
3-17	2 Oct 62	Sea level	4 hr at -65°F	1	85	1
				2	87	1
				3	85	1
				4	88	1
				5	87	1
				6	90	1
				7	85	1
				8	87	1
				9	61	1, 11, 12
				10	89	1, 6
				11	17	1, 11, 12
				12	85	1
				13	82	
				14	86	
				15	80	
				16	78	

U.S.F. Lot No.	Date of Test	Chamber Pressure	Flare Temperature Soak	Flare No.	Burning Time (sec)	Remarks (See p. 44.)
3-17 (Cont'd)	2 Oct 62	Sea level	4 hr at -65°F	17	69	
				18	84	
				19	86	
				20	82	
	3 Oct 62			21	-	1, 10
				22	87	1
				23	88	1
				24	85	1
				25	62	
				26	-	10
				27	89	
				28	82	
				29	88	
				30	86	
				31	84	
				32	84	
				33	86	
				34	-	10
				35	65	
				36	62	
				37	50	11, 12
				38	81	
				39	87	
				40	80	
					83	Average Burning Time
3-17	2 Oct 62	35,000 ft	None	1	172	
				2	164	
				3	166	
				4	165	
				5	171	
				6	165	
				7	148	5
				8	162	4
				9	168	
				10	166	3
				11	154	2, 5
				12	170	2
				13	167	1
				14	166	1
				15	157	1, 4
				16	163	
				17	162	4
				18	159	
				19	157	
				20	153	
	3 Oct 62			21	152	
				22	165	
				23	-	7
				24	161	6
				25	154	
				26	154	
				27	151	
				28	165	3
				29	155	9, 12
				30	143	
				31	162	4

U.S.F. Lot No.	Date of Test	Chamber Pressure	Flare Temperature Soak	Flare No.	Burning Time (sec)	Remarks (See p. 44.)
3-17 (Cont'd)	3 Oct 62	35,000 ft	None	32	155	3
				33	166	4
				34	151	
				35	-	7
				36	157	
				37	152	
				38	-	7
				39	150	
				40	144	3
					159	Average Burning Time
3-17	4 Oct 62	35,000 ft	4 hr at -65°F	1	170	1
				2	161	1, 3
				3	164	1
				4	155	2
				5	165	
				6	165	5
				7	162	
				8	157	
				9	169	4
				10	159	
				11	163	5
				12	152	
				13	170	6
				14	157	
				15	171	
				16	161	
				17	171	
				18	170	
				19	160	4
				20	-	7
	5 Oct 62			21	164	1
				22	170	1, 5
				23	-	1, 7
				24	172	1, 5
				25	165	1
				26	162	1, 3
				27	160	1, 5
				28	165	1
				29	160	1
				30	160	1, 3
				31	166	1, 3
				32	161	
				33	172	5
				34	168	3
				35	161	
				36	163	6
				37	164	
				38	167	
				39	156	5
				40	161	3
					164	Average Burning Time

REMARKS ASSOCIATED WITH NUMERICAL CODING IN REMARKS COLUMN

1. Wax found on base plug and case of flare when it was unpacked. (See Fig. 7.)

2. Excessive wax found on base of flare, making it necessary to use pliers to remove shunting cap or to scrape wax from electrical contacts.

3. Momentary delay between squib firing and ignition of main illuminant.

4. Approximately 1-sec delay between squib firing and ignition of main illuminant.

5. Approximately 2-sec delay between squib firing and ignition of main illuminant.

6. Approximately 3-sec delay between squib firing and ignition of main illuminant.

7. Squib fired and caused closure plug to separate from flare body but first fire composition and main illuminant did not ignite. (See Fig. 12.)

8. Squib fired and caused closure plug to separate. Flare sputtered momentarily but first fire composition and main illuminant did not ignite.

9. Only partial separation of closure plug, causing abnormal plume. (See Fig. 16.)

10. All flare material blew out of case. (See Fig. 13.)

11. Some flare material blew out of case. Remainder burned in case.

12. Burning time not included in average.

APPENDIX II

DETAILED FLIGHT TEST DATA ON U.S.F. LOT 3-17 TAU-15/B FLARES

Presented in the following table is a summary of all data obtained during the flight tests conducted with the U.S.F. Lot 3-17 TAU-15/B flares. All flares listed were flown without prior cold soaking at an altitude of 35,000 ft and an airspeed of mach 0.7. The burning times shown in Column 4 are accurate to within ±1 sec.

Date	Target	Flare No.	Burning Time (sec)	Remarks
23 Oct 62	DF-4IR1A	1	171	
		2	174	
		3	176	
		4	176	Observer reported weak plume.
	TDU-4/B	5		No ignition of flares. Target was
		6		lost during recovery.
		7		
		8		
23 Oct 62	DF-4IR1A	9	167	Flare No. 10 tried to illuminate
		10	-	but failed; closure plug blew off.
		11	167	Target was lost during recovery.
		12	174	
	TDU-4/B	13		No ignition of flares. Target was
		14		lost during recovery.
		15		
		16		
24 Oct 62	TDU-4/B	17	164	Wax found on two flares when they
		18	175	were unpacked. Burning flares
		19	163	caused target to spin faster. Only
		20	173	one target used on this mission.
25 Oct 62	TDU-4/B	21	165	One flare case burned through at
		22	167	neck and broke off during flight.
		23	175	
		24	167	
	TDU-4/B	25		No ignition of flares. Target
		26		batteries were weak after landing.
		27		
		28		
25 Oct 62	TDU-4/B*	29	-	Closure plug blew off.
		30	140	Wax deposits on flare.
		31	170	Wax deposits on flare.
		32	-	No ignition; wax found on electrical contacts after landing.
29 Oct 62	TDU-4/B	33	160	
		34	167	Two ignition attempts required.
		35	170	2-3 sec delay after ignition attempt.
		36	174	

* Only one target used on this mission.

Date	Target	Flare No.	Burning Time (sec)	Remarks
29 Oct 62 (Cont'd)	TDU-4/B	37	180	Short plume, Considerable amount of black smoke. Apparently closure plug came part way off.
		38	165	Momentary delay after ignition attempt.
		39	-	No ignition. Wax found on electrical contacts after landing.
		40	163	One flare discarded on this mission; shunting cap could not be removed because of wax deposits.
	TDU-4/B	41		Target was lost on launch.
		42		
		43		
		44		
	TDU-4/B	45		No ignition of flares. Target batteries were weak after landing.
		46		
		47		
		48		
30 Oct 62	TDU-4/B	49		No ignition of flares. Target control receiver would not operate after landing.
		50		
		51		
		52		
	TDU-4/B	53		No ignition of flares. Target control receiver would not operate after landing.
		54		
		55		
		56		
31 Oct 62	TDU-4/B	57		No ignition of flares. Target lost during recovery.
		58		
		59		
		60		
	TDU-4/B	61		No ignition of flares. Target receiver would not operate after landing.
		62		
		63		
		64		
	Average Burning Time - 168 sec			

APPENDIX III

FLIGHT TEST DATA ON U.S.F. LOT 3-1 TAU-15/B FLARES OBTAINED UNDER APGC PROJECT 6828W2

Presented in this appendix are data obtained on U.S.F. Lot 3-1 flares during tests under APGC Project 6828W2, Test of the F-101A Tow Subsystem. The flares used in this program were burned without prior cold soaking at 30,000 ft altitude and at an airspeed of mach 0.84.

Date	Flare No.	Remarks
3 Aug 62	1	Closure plug blew off, no burning
	2	Burned approximately 2 in.
	3	Burned approximately 2 in.
	4	Satisfactory
6 Aug 62	5	Satisfactory
	6	Satisfactory
	7	Satisfactory
	8	Closure plug blew off, no burning

APPENDIX IV

DATA ON U.S.F. LOT 3-5 TAU-15/B FLARES EXTRACTED FROM U.S. NAVAL AMMUNITION DEPOT REPORT RDTR NO. 28*

This appendix contains data obtained by the Department of the Navy during static functional tests of U.S.F. Lot 3-5 TAU-15/B flares in March 1962. The flares were approximately 20 months old at the time of testing. These data are included in this report for comparison with those obtained at Eglin AFB several months later. The burning times of those flares burned in the altitude chamber were reported difficult to obtain due to smoke obscuring vision. The same difficulty was experienced during the tests at Eglin AFB.

* *RDTR No. 28, TAU-15/B IR Tracking Flare, U.S. Naval Ammunition Depot, Crane, Indiana, dated 31 July 1962.*

Flare No.	Flare Conditioning and Test Environment	Burning Time (sec)	Remarks
1	28-day temperature	92.2	
2	humidity cycle, 5-hr	89.2	
3	cold soak at -65°F,	-	Exploded after 28.2 sec
4	ambient pressure.	93.8	
5		99.0	
6		-	Exploded after 14.6 sec
7		99.0	
8		-	Exploded after 18.0 sec
9		-	Exploded after 30.0 sec
10		94.6	
1	None. Burned at	83.8	
2	ambient temperature	82.8	
3	and pressure.	83.0	
4		78.2	
5		71.4	
6		78.6	
7		88.0	
8		85.6	
9		81.0	
10		79.0	
1	MIL-E-5272 vibration,	125.0	
2	5-hr cold soak at	141.0	
3	-65°F, simulated	135.0	
4	35,000 ft altitude	100.0	
5		128.0	
6		138.0	
7		119.0	
8		162.0	
9		120.0	

APPENDIX V

SUGGESTED PROCEDURES FOR CONDUCTING SIMILAR TESTS

As an aid to others contemplating similar tests of other electrically ignited flares, the following suggestions are made regarding testing of the flares in an altitude chamber. These comments are based on experience gained with tests of this type during the conduct of this project.

1. The test items should be positioned at least 12 in. apart in the chamber and should be separated by a metal shield to avoid unintentional ignition or heating of adjacent items.

2. The chamber floor must be fireproof. The chamber walls should also be protected to prevent them from being damaged by exploding test items.

3. Ignition harnesses should be routed to avoid proximity to burning test items. Use of asbestos-covered harnesses did not suffice during this test.

4. Test racks to hold the test item must be firmly fixed due to the forceful explosions which may occur.

5. When the test chamber is used to cold soak test items, and there are more items than can be tested in the chamber at one time, provisions should be available for keeping these items insulated after cold soaking and prior to testing.

6. Functional tests at sea-level conditions should be considered only if the test item has a definite application at sea-level.

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1 Hq USAF (AFORQ-OT)
2 AFSC (SCPTP)
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2 TAC (DMEMAS)
2 TAC (DMEMAA)
1 PACAF (PFORQ)
1 USAFE (OTREQ)
1 5 AF (5FCAG-P)
1 5 AF (5FOPR-RQ)
1 13 AF (13ODO)
1 25 Air Div (MME)
1 26 Air Div (MME)
1 28 Air Div (MME)
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1 30 Air Div (MME)
1 32 Air Div (MME)
1 33 Air Div (MME)
1 64 Air Div (MME)
1 73 Air Div (MME)
1 AFMTC (Tech Lib/MU-135)
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3 ASD (ASAD-Lib)
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4 MOAMA (MONASA)
1 OOAMA (OONE)
2 OOAMA (OONEAT)
2 OOAMA (OONN)
2 OOAMA (OONNO)
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1 USNADC
4 USNOTS (Code 4052)
3 Flt Marine Force Atlantic
1 Marine Corps Eq Bd
2 U of Mich
1 OTS, US Dept of Commerce
1 4750 Test Sq (T&AE)
1 7272 Ab Wg (DOWT-SS)
1 7272 Ab Wg (DOWT-F)
1 7272 Ab Wg (DMCM-MUN)
2 7272 Ab Wg (DCS/O)
1 BUWEPS (Code RM-46)
1 NATC (Ord Br, Wpns Sys Test)
1 U.S. Nav Ammunition Depot
4 Atlantic Research Corp
1 BSD (Tech Lib)
1 RADC (Tech Lib)
14 USAF Academy
15 ASTIA (TIPCR)
APGC
  1 PGBME-7
  1 PGVW
  3 PGEH
  2 PGAPI
  1 PGAPT
  10 ASQTT
  15 PGWQ
  2 TACLO
  2 PGWT

Air Proving Ground Center, Eglin Air Force Base, Florida
Rpt No. APGC-TDR-63-27. ENGINEERING INVESTIGATION OF IGNITION FAILURE RATE OF TAU-15/B INFRARED TARGET FLARES. Final report. May 1963. 52p. incl illus. tables. Unclassified Report

This test was established at the request of the Target Development Laboratory, Detachment 4, Aeronautical Systems Division. Unsatisfactory operation of the TAU-15/B infrared target flares had been observed when these flares were employed at high subsonic speeds and high (35,000 ft) altitude. The primary difficulty was failure of a significant percentage of the flares to burn after successful operation of the ignition squibs. Since it was believed that age of the flares may have affected their operational performance, this test was conducted to investigate the ignition failure rate of TAU-15/B flares which had been in storage since the July-October 1960 manufacturing period. Specific objectives of the test were to determine the ignition failure rate during flight at 35,000 ft altitude and mach 0.7 as well as under simulated flight conditions in an altitude chamber. It was concluded that performance of the TAU-15/B flares varies from one production lot to another and with altitude and the internal temperature of the individual flares. Results obtained under simulated altitude conditions in the altitude chamber correlated reasonably well with those obtained during airborne tests. Recommendations include elimination of U.S. Flare Lot 3-1 TAU-15/B flares from USAF inventories and replacement of all TAU-15/B flares by an improved substitute as soon as possible.

1. Flares
2. Infrared equipment
3. TAU-15/B
I. AFSC Project 7826
II. Bunn, Russell A., Capt, USAF
III. In ASTIA collection

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